

Virtual Reality Robotic Operation Simulations Using MEMICA Haptic System

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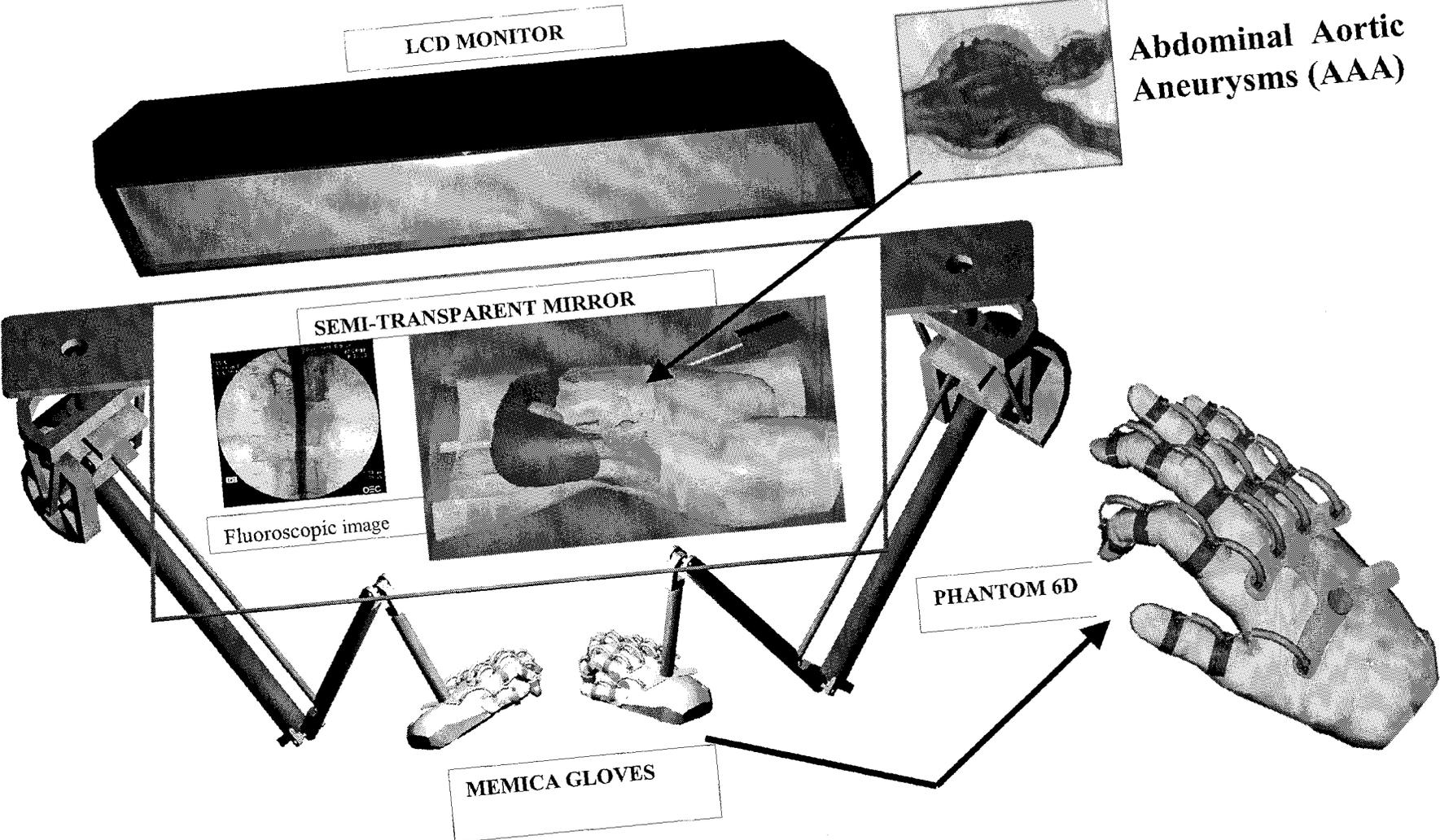
Rodney White, M.D., Harbor-UCLA Medical Center, CA

SmartSystems 2000

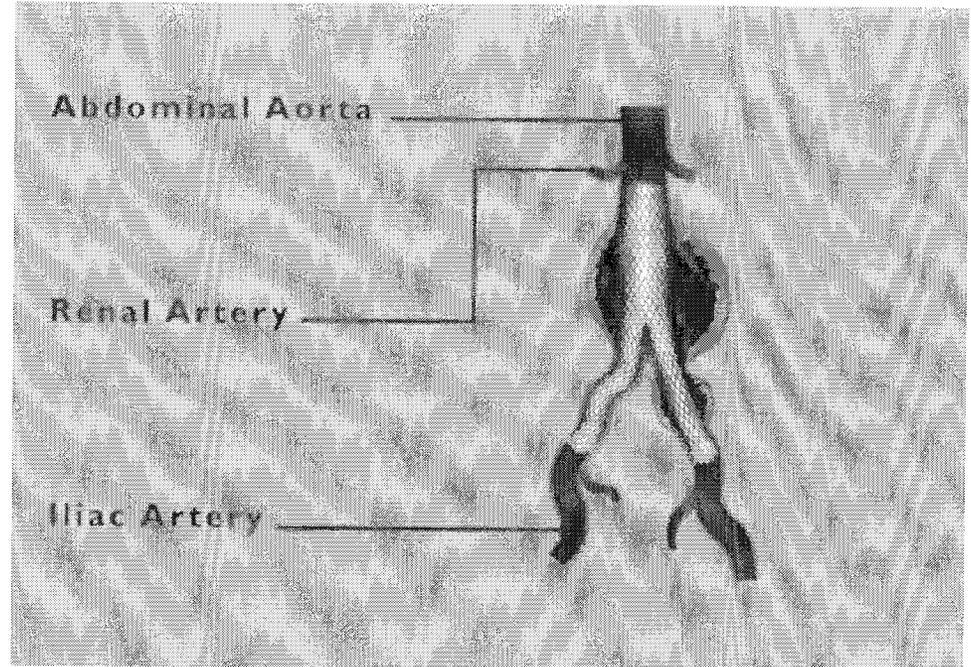
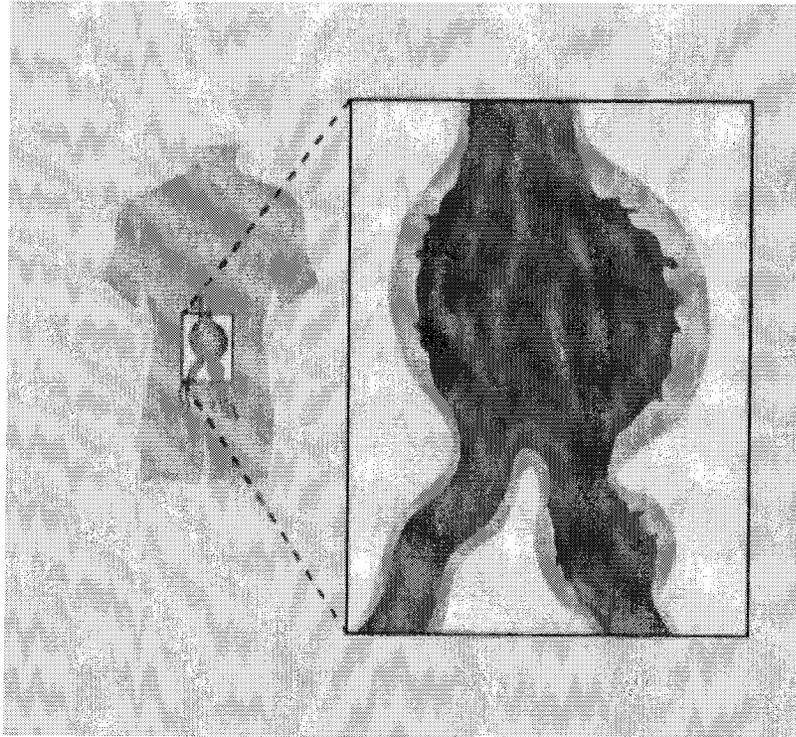
September 6-8, 2000, Houston, TX

<http://www.smart.systems.org/index.htm>

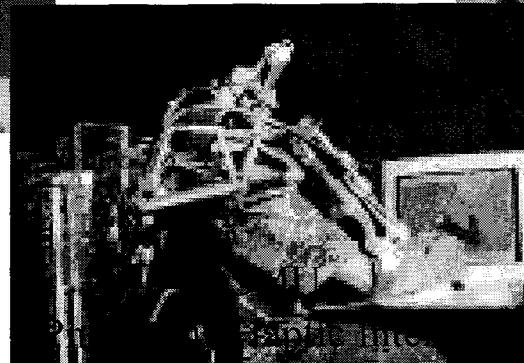
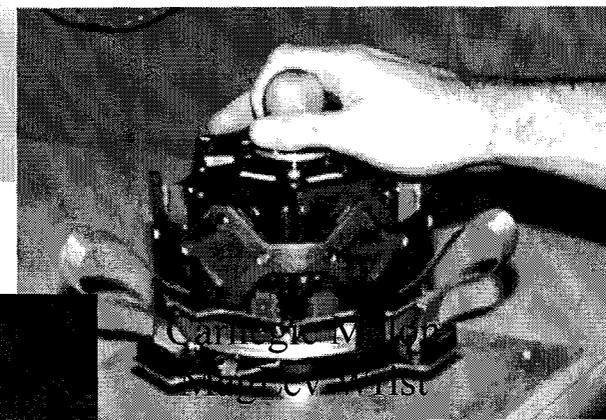
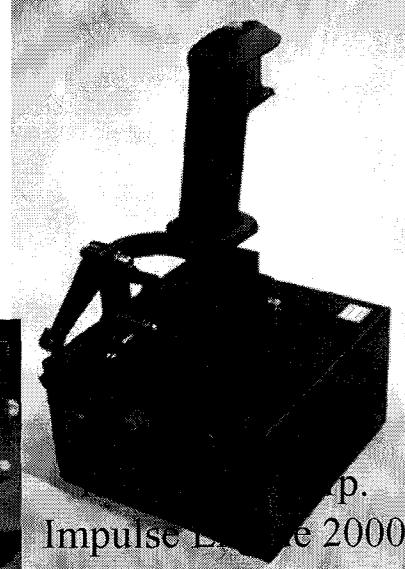
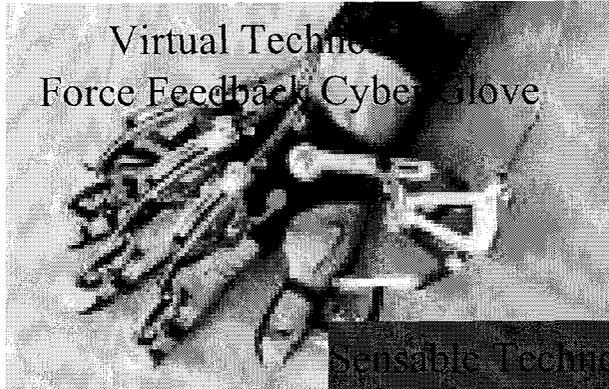
Performing Virtual Reality Medical Tasks via the MEMICA Haptic Interface



Aortic Aneurysm and its Anatomical Location



Haptic Interfaces

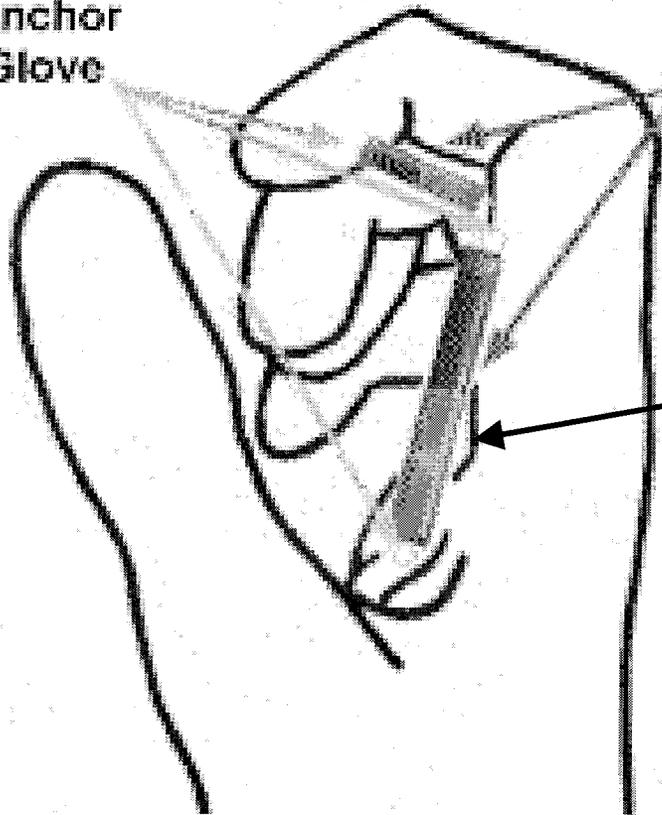


<http://haptic.mech.nwu.edu/intro/gallery/>

MEMICA

Mechanical Mirroring using Controlled stiffness and Actuators

Pivoting Anchor
Points on Glove



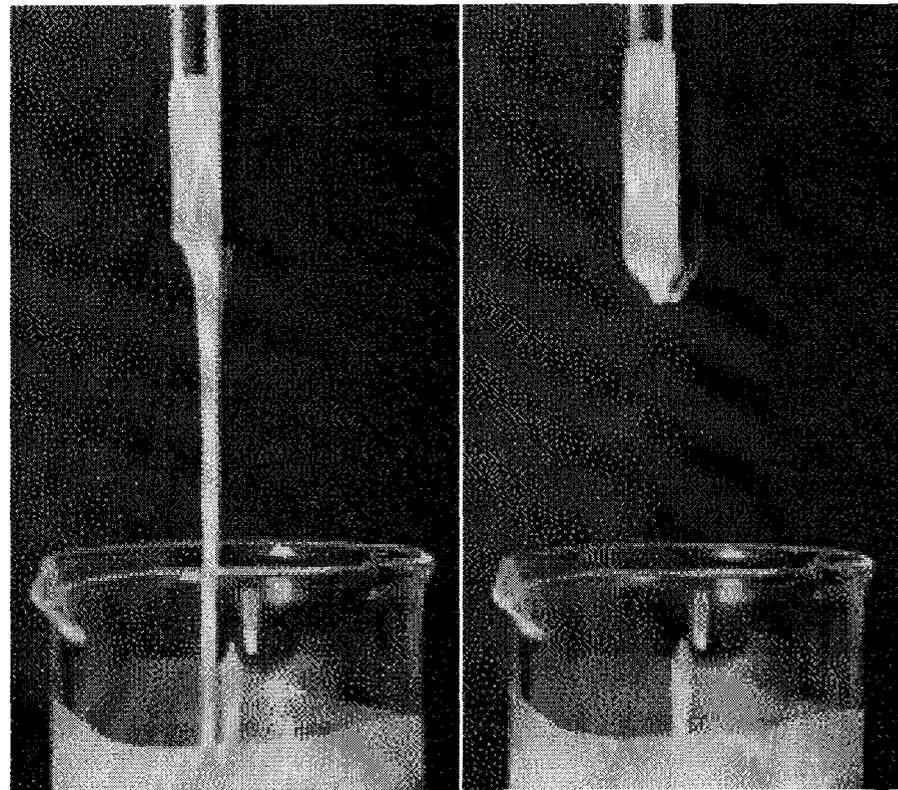
ER Cylinders

MEMICA allows mirroring remote or virtual compliance and forces using an ERF based system

Inside Palm Configuration

Electro-Rheological Fluids (ERFs)

- Suspensions of particles in an insulating base fluid
- Changes viscosity when subjected to an electric field



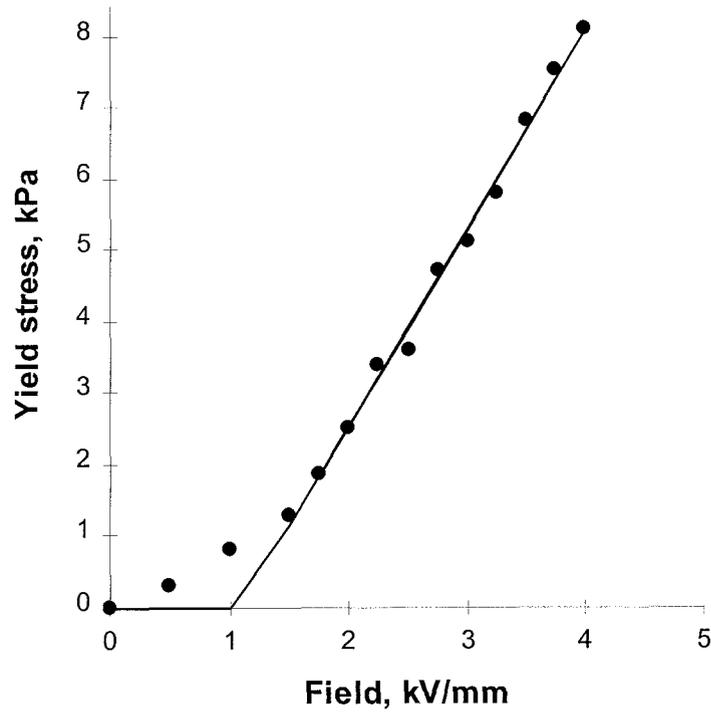
Reference fluid
state

Subjected to
electrical field

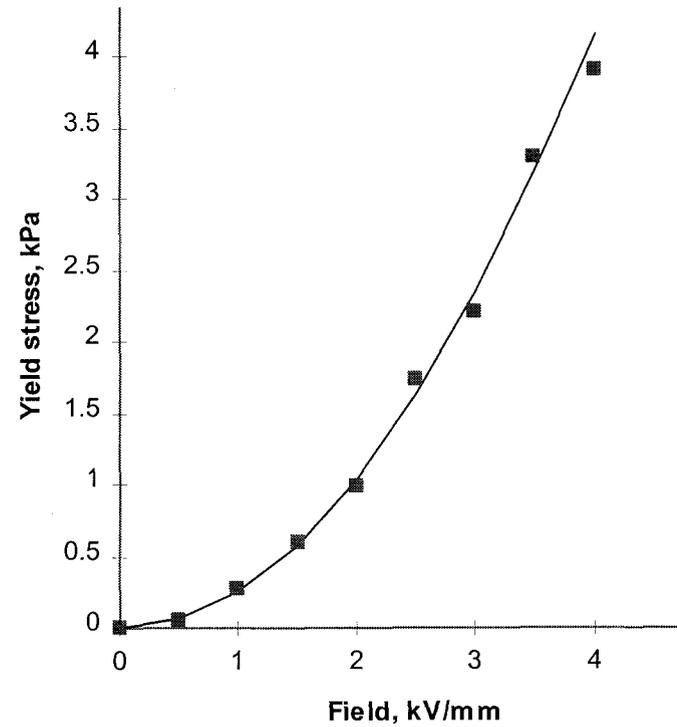
“LID 3354” ER Fluid

35% of polymer particles in a flourosilicone base oil

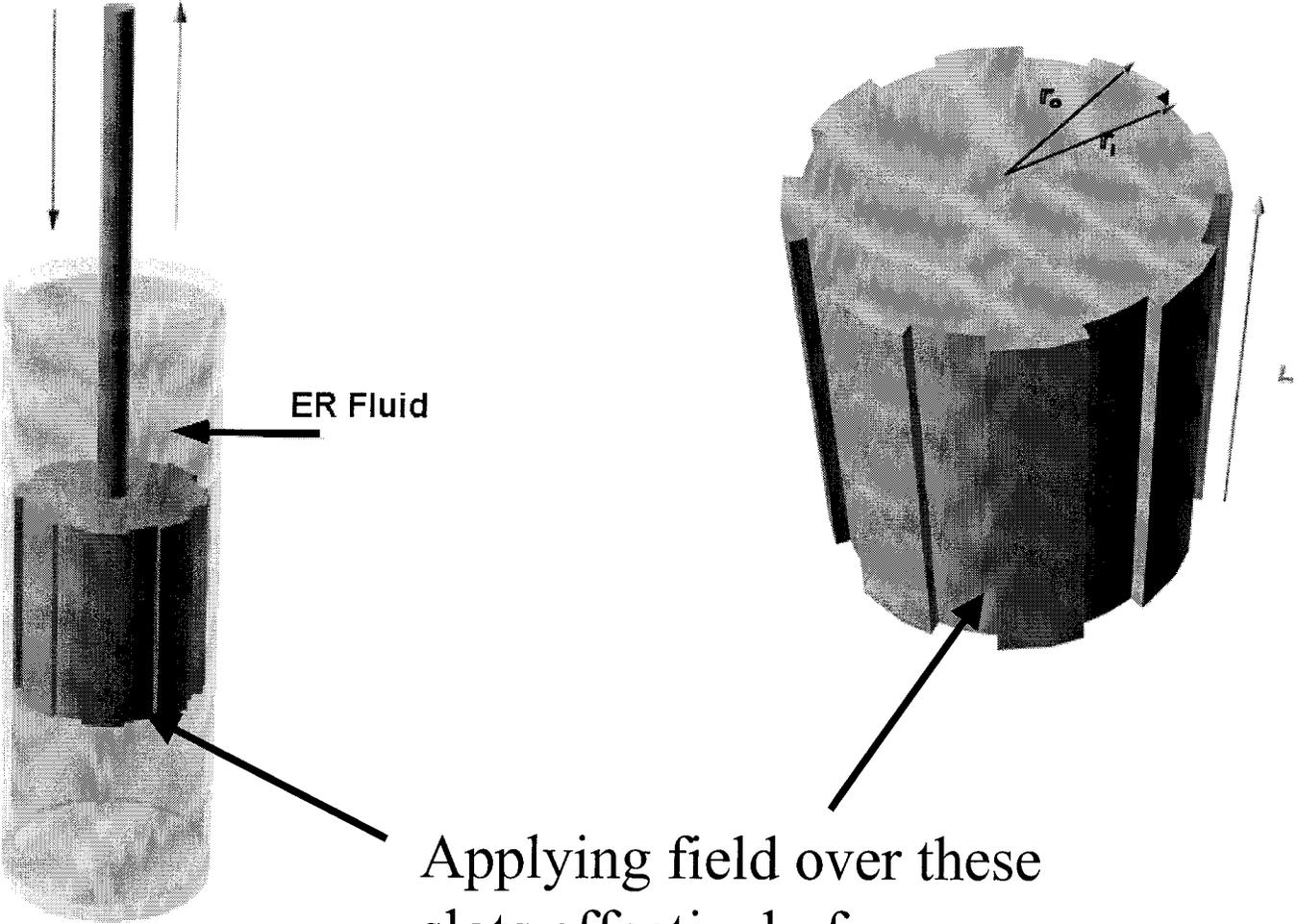
Static Yield Stress



Dynamic Yield Stress



Electrically Controlled Stiffness (ECS) Element



Applying field over these slots effectively forms a closed value

Mathematical Modeling of ECS Element

Static Force

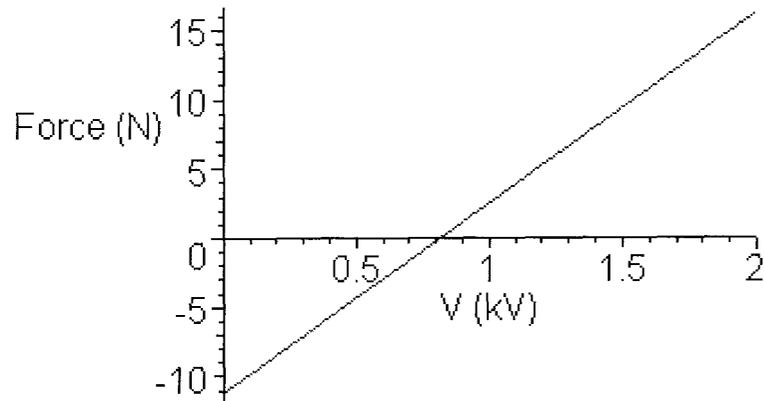
$$F_{R,s} = NC_s L \left[\left(2 + \frac{2\theta}{\ln\left(\frac{r_o}{r_i}\right)} \right) V - (2\Delta r + \theta(r_o + r_i)) E_{ref} \right]$$

Dynamic Force

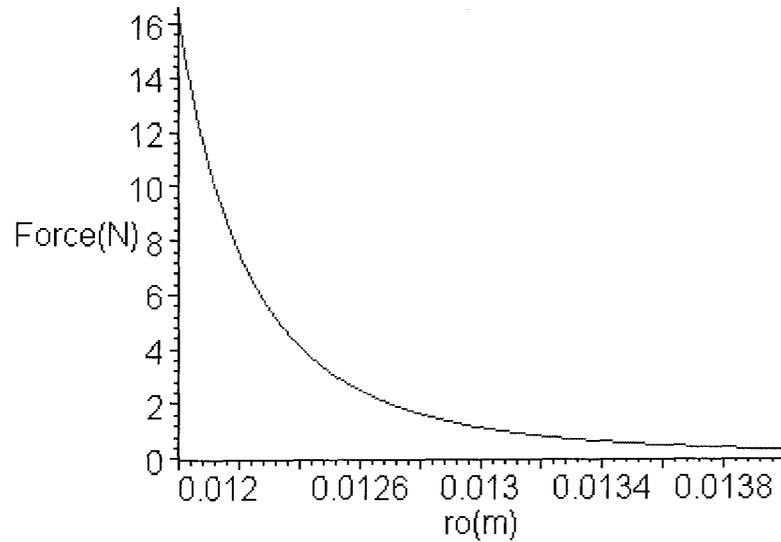
$$F_{R,d} = \left(\frac{\pi r_o^2}{\frac{N\theta}{2}(r_o^2 - r_i^2)} \right) NL \left[\left(C_d - C_v \frac{v}{\Delta r} \right) \left(\frac{\theta}{r_o} + \frac{\theta}{r_i} + \frac{2}{r_i} - \frac{2}{r_o} \right) \frac{V^2}{\left(\ln\left(\frac{r_o}{r_i}\right) \right)^2} + \mu_o \left(2 + \theta \left(\frac{r_o + r_i}{\Delta r} \right) \right) v \right] - \rho L \left(\pi r_o^2 - \frac{N\theta}{2}(r_o^2 - r_i^2) \right) a$$

Design Analysis of ECS Element

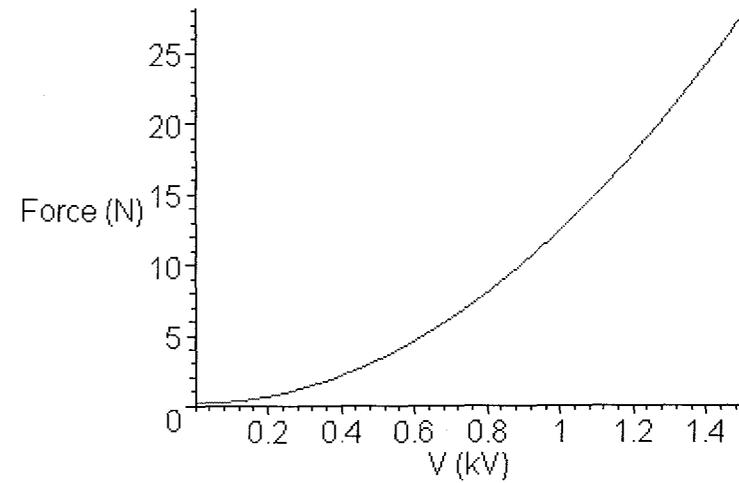
Static Force=f(V)



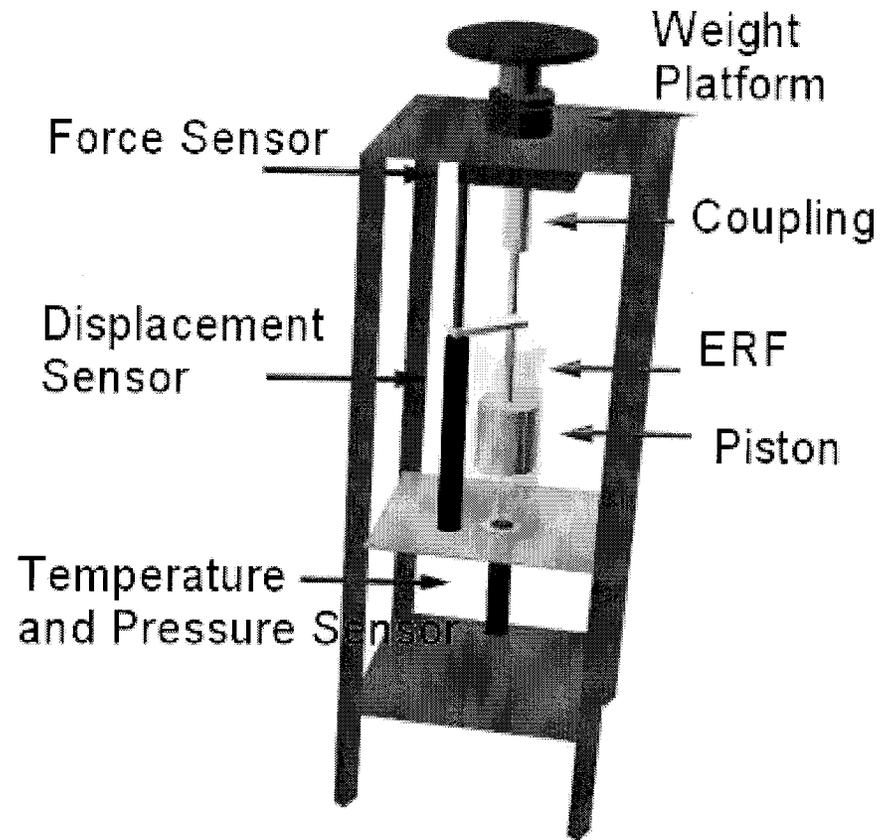
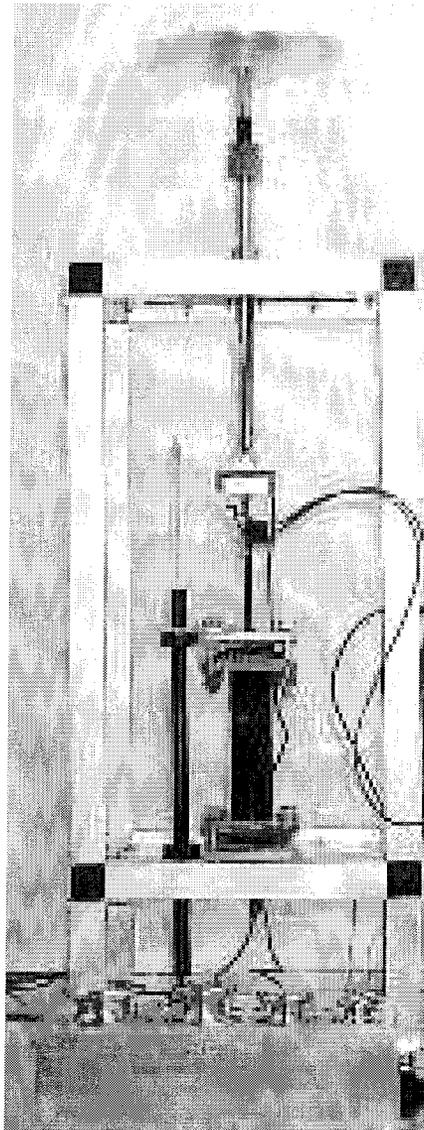
V=1kV



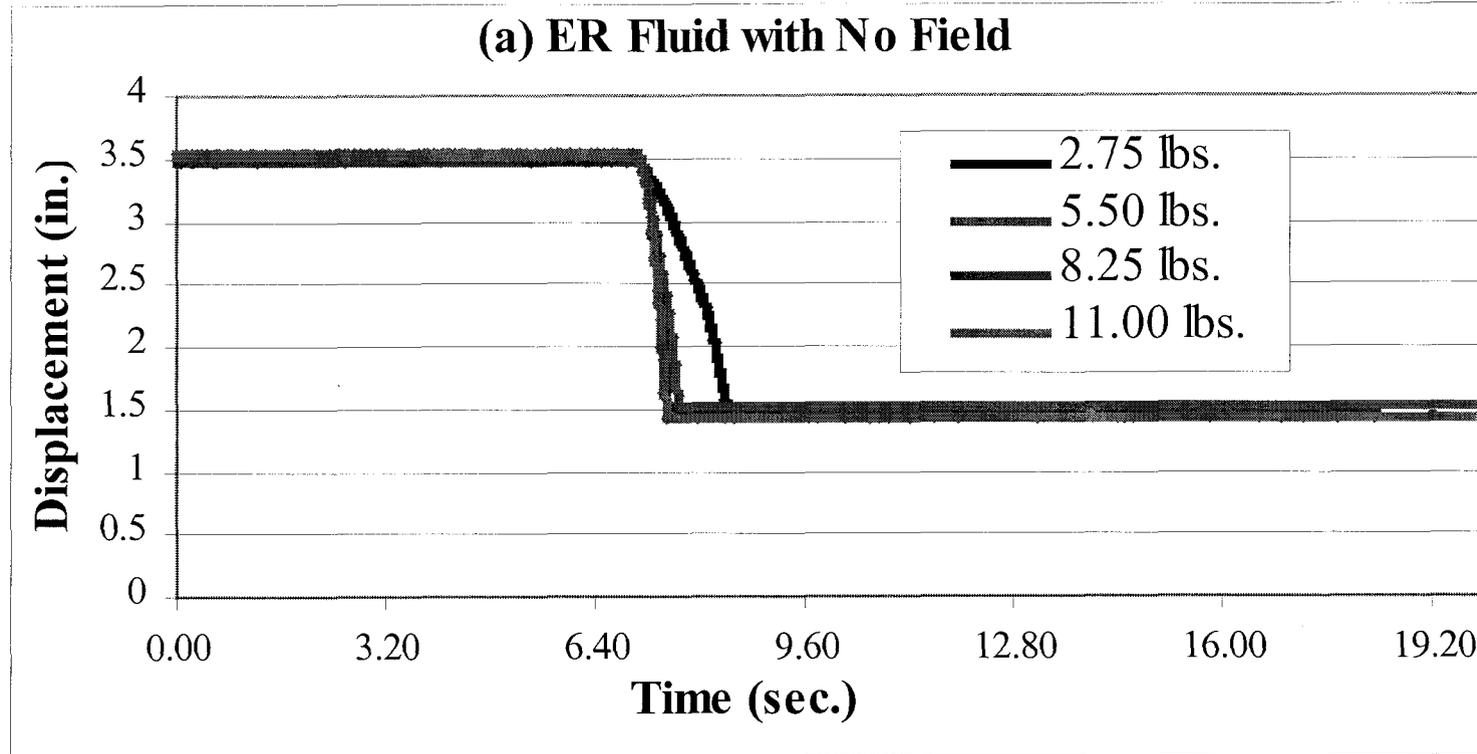
Dynamic Force=f(V)



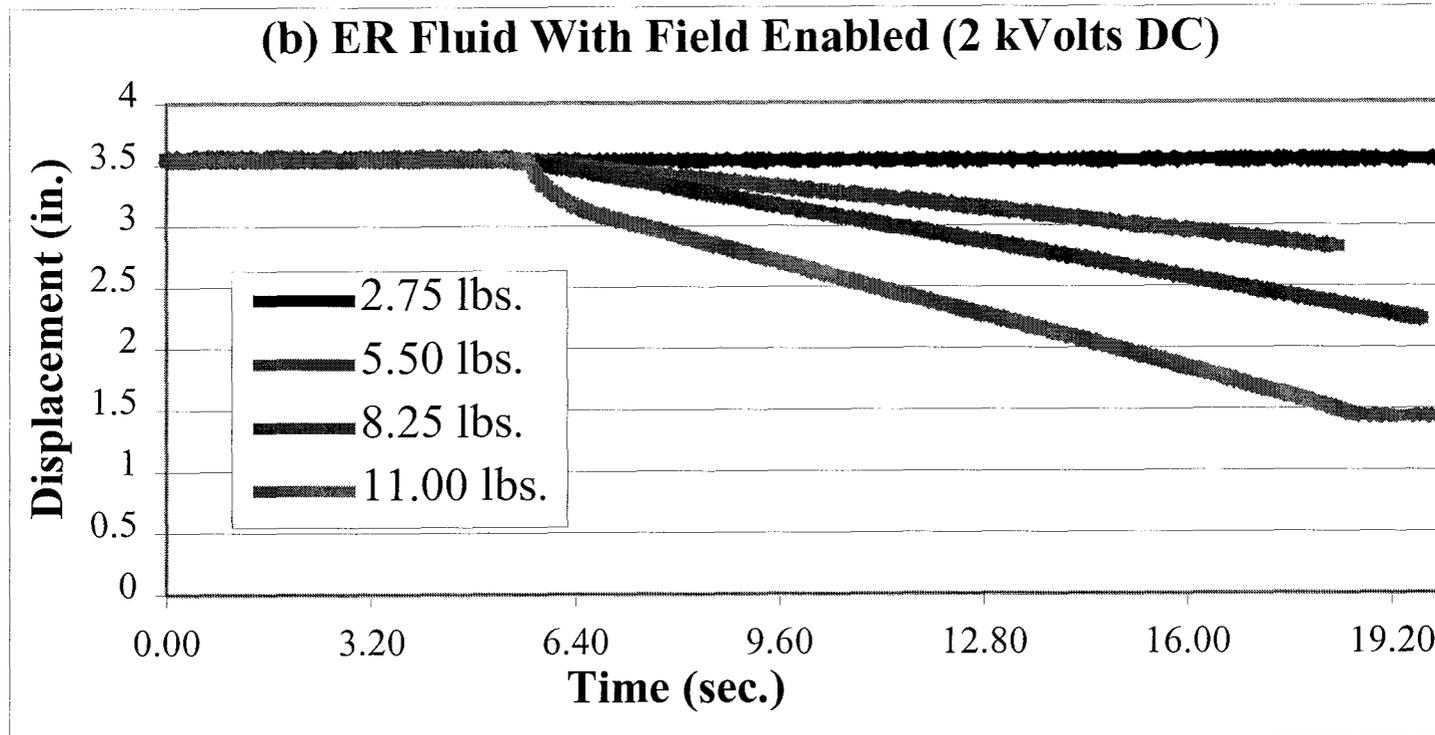
ECS Experimental Set-up



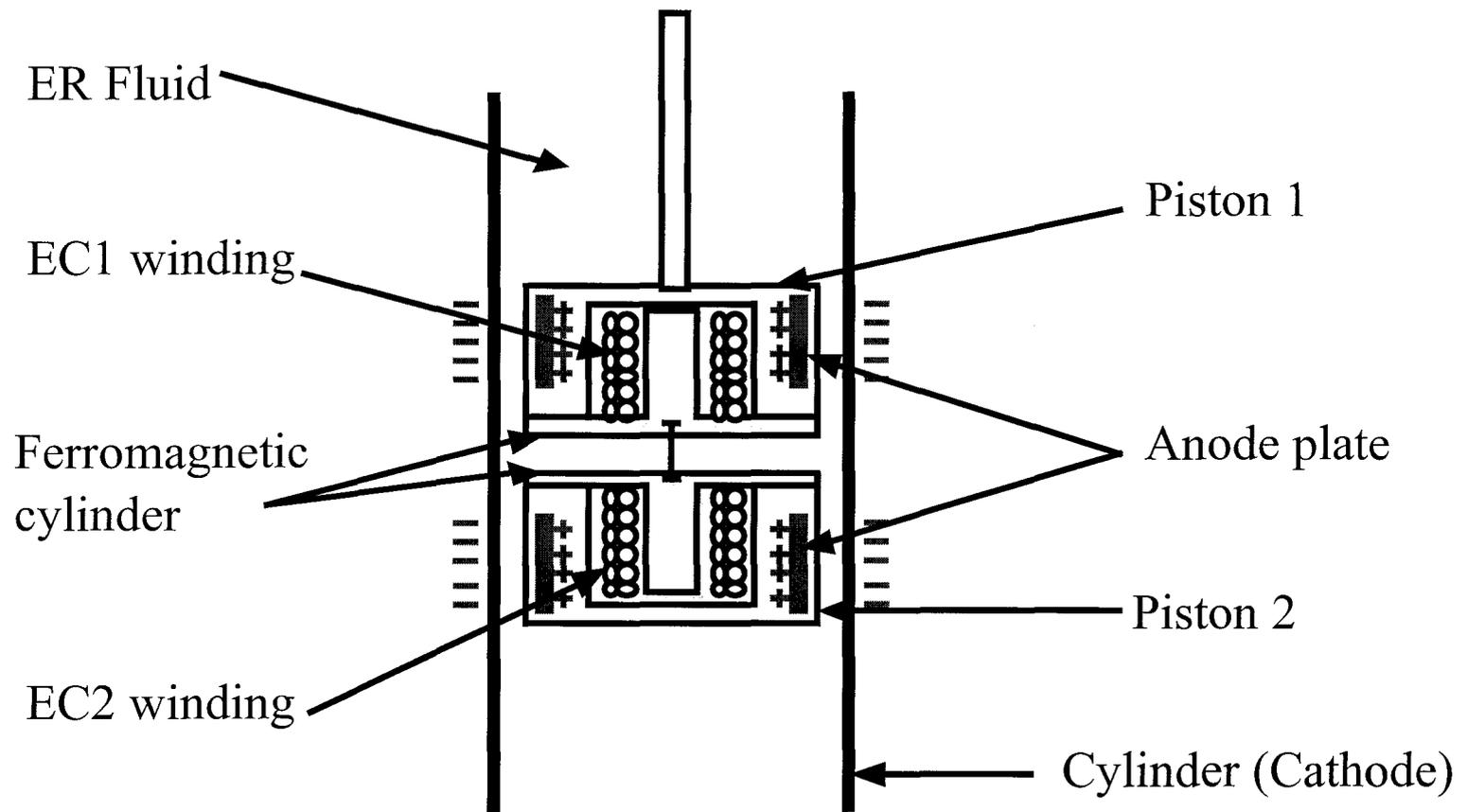
Experimental Data: No Field



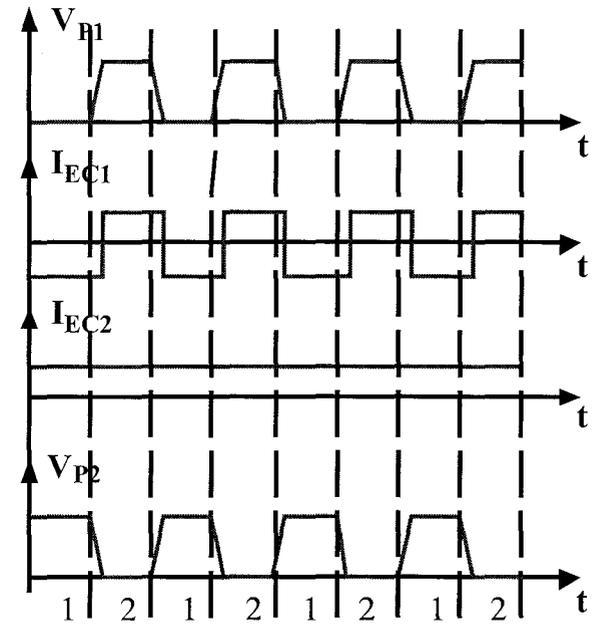
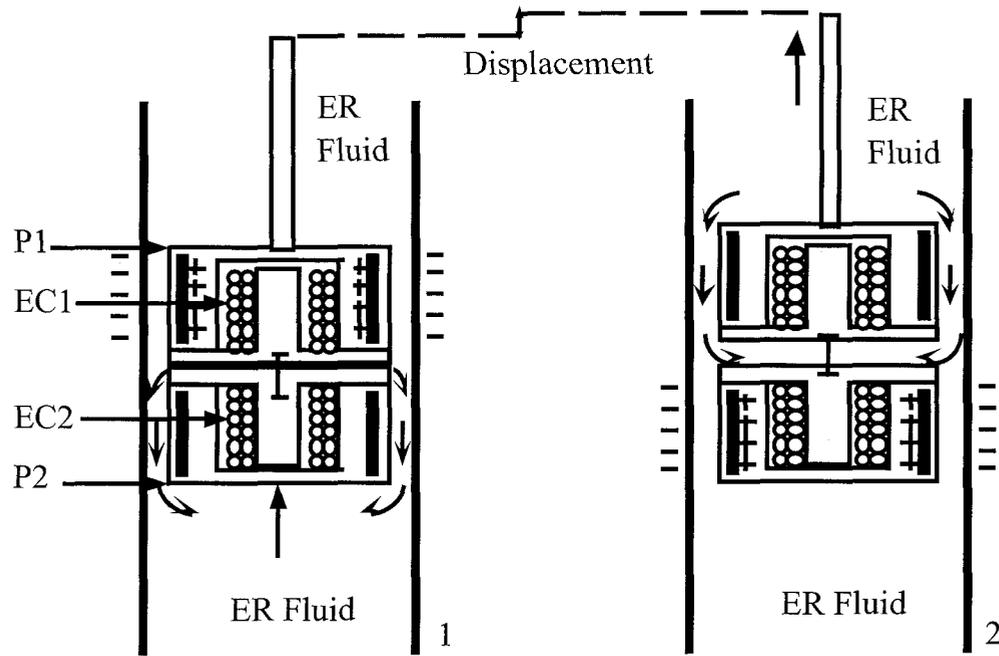
Experimental Data: With Field



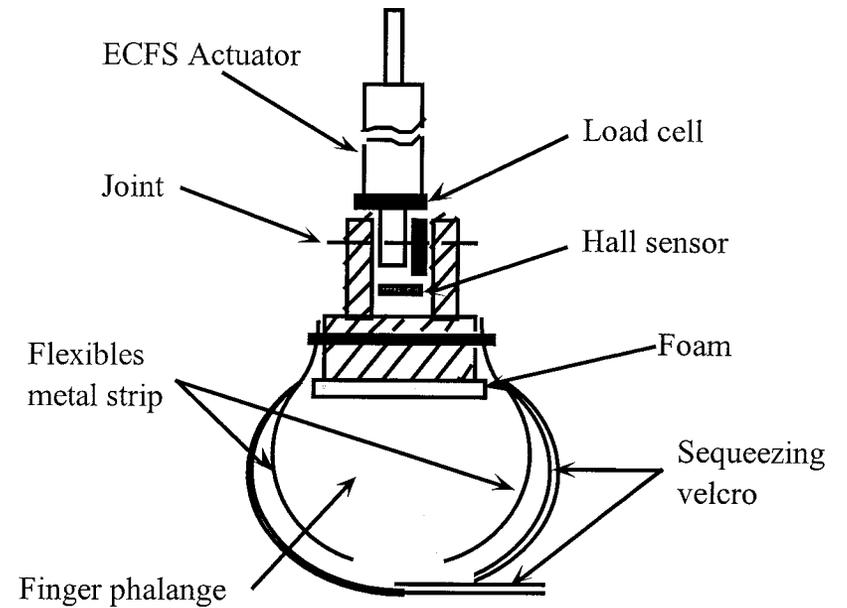
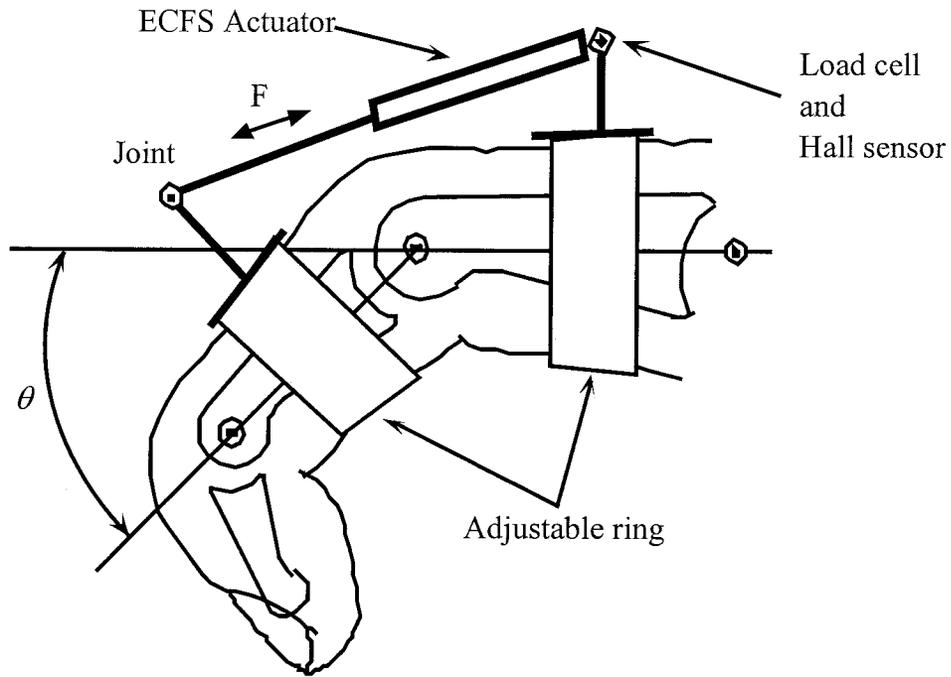
Electrically Controlled Force and Stiffness (ECFS) Actuator



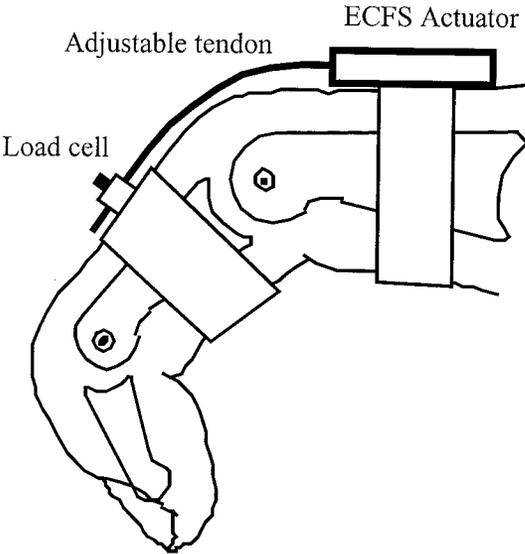
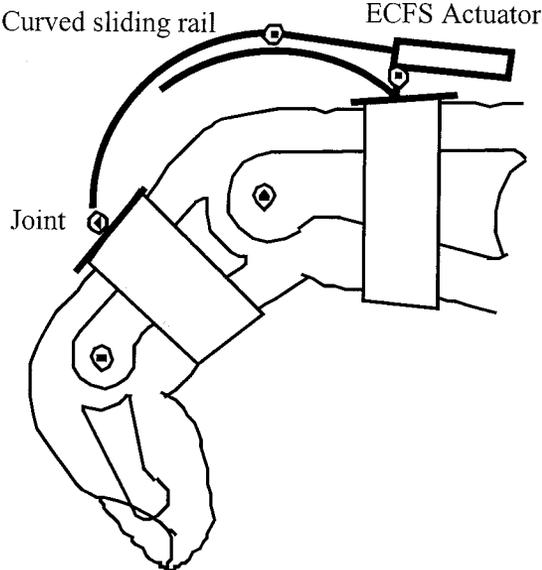
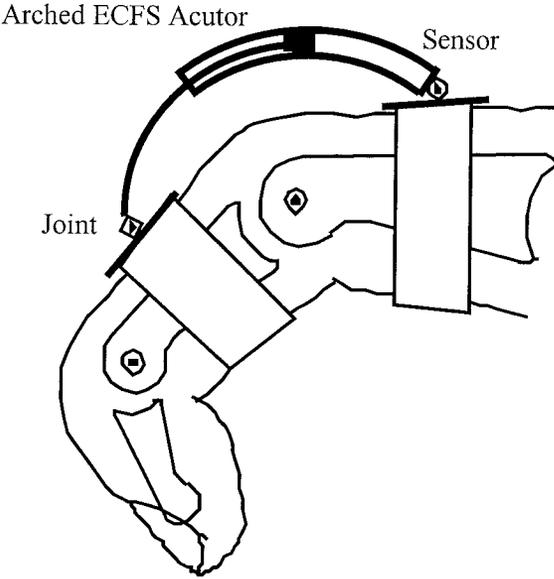
Inchworm Motion of ECFS Actuator



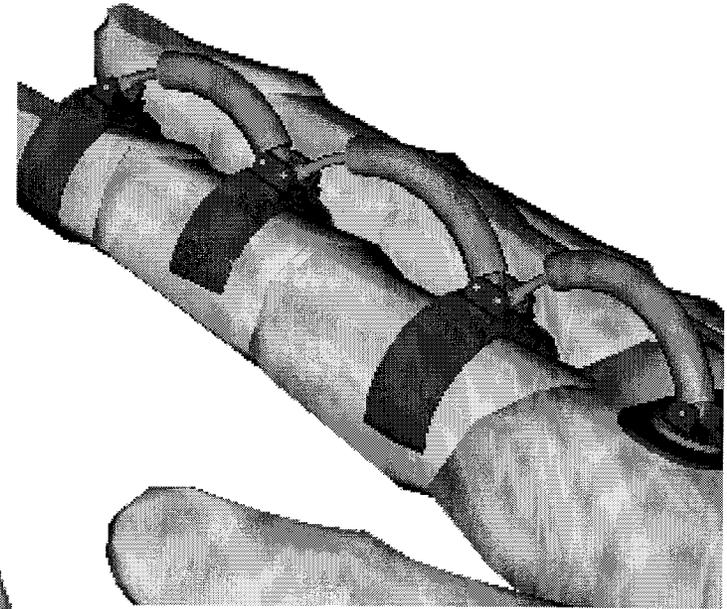
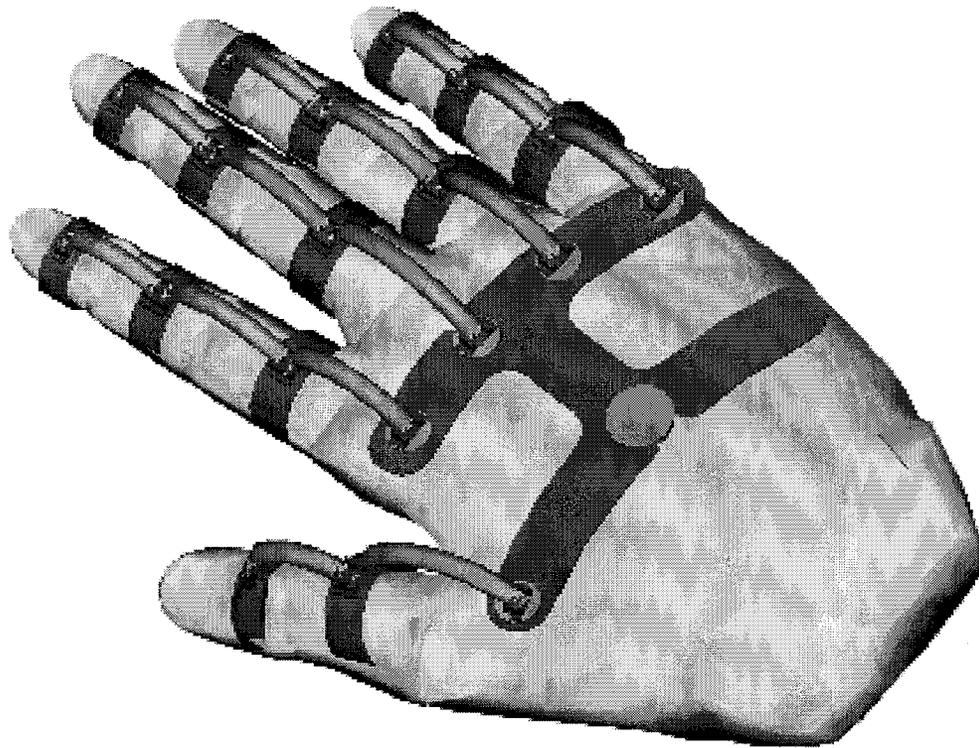
Mounting of ECFS Actuators on Fingers



Different Exoskeleton Mechanisms

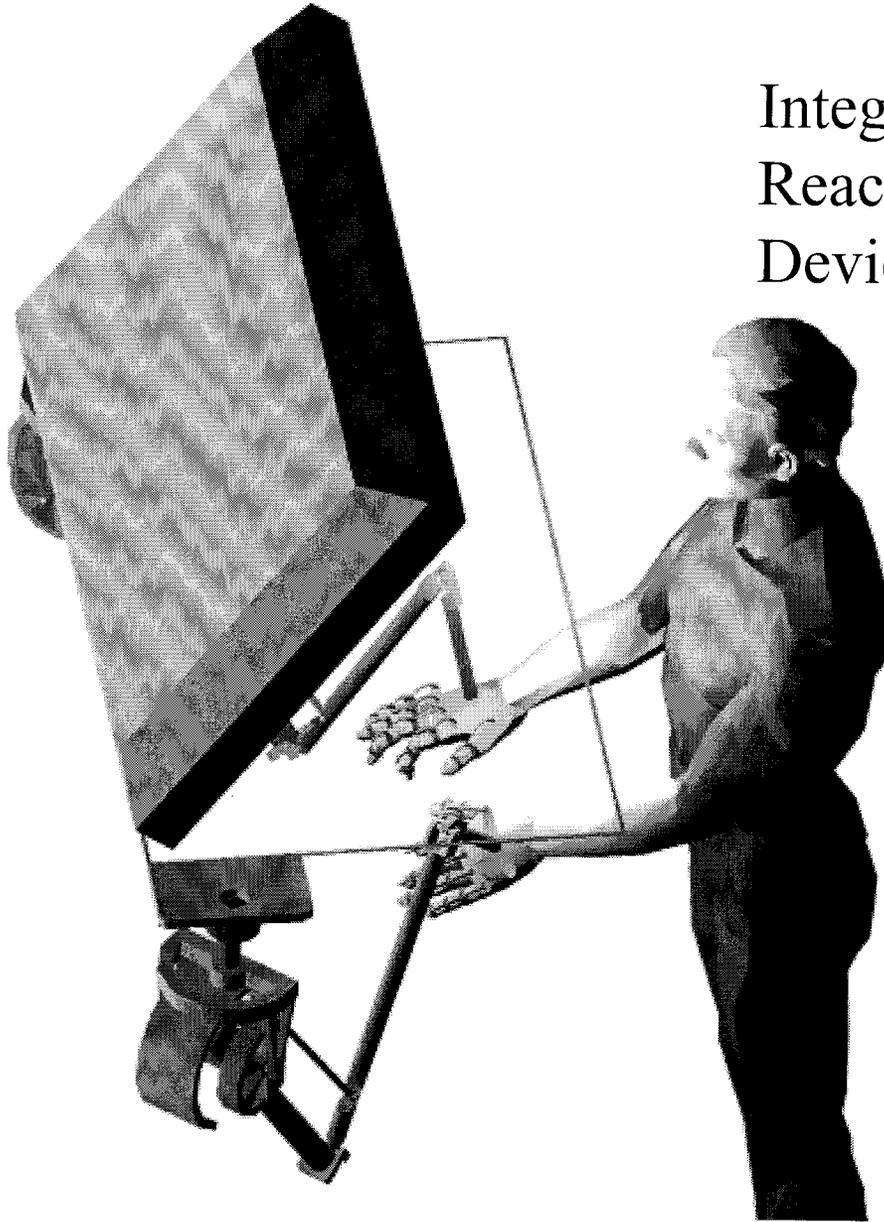


ECFS Actuators on a MEMICA Glove



MEMICA System Overall View

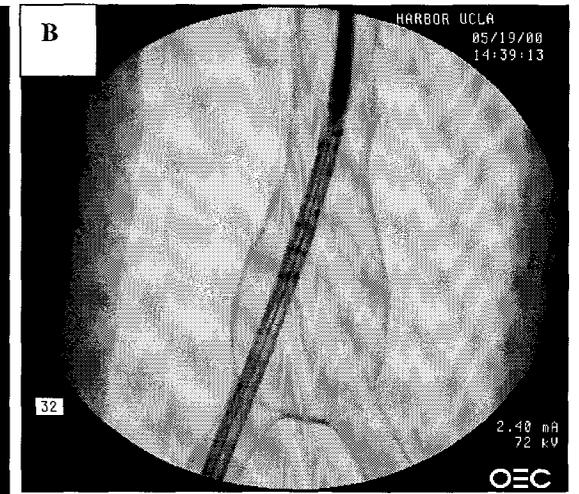
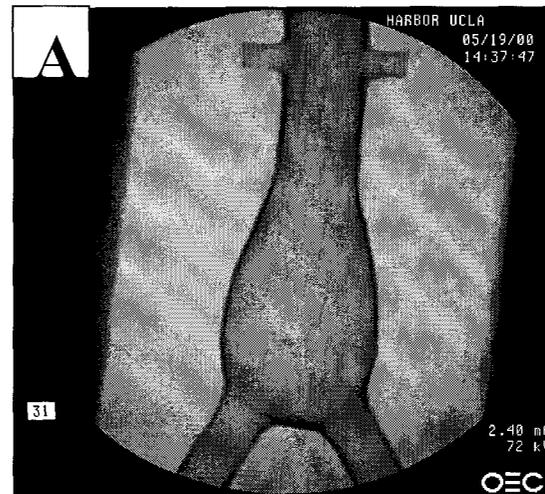
Integration of MEMICA with
ReachIn Display and PHANTOM
Devices



Virtual Endovascular Surgery Demonstration

Six clinically applicable steps:

1) Simplified Flow Model

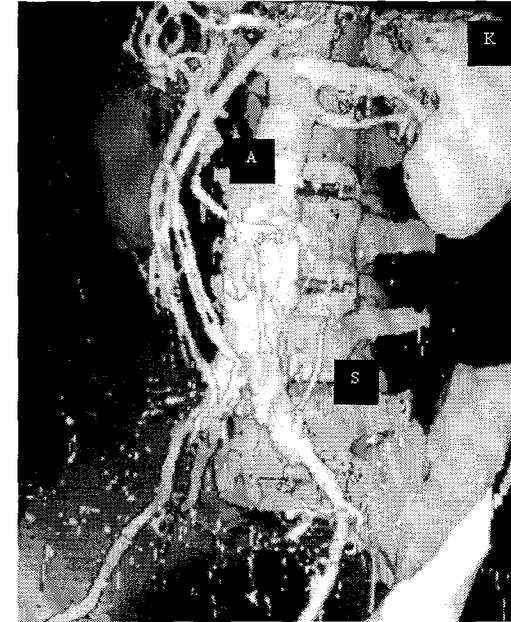
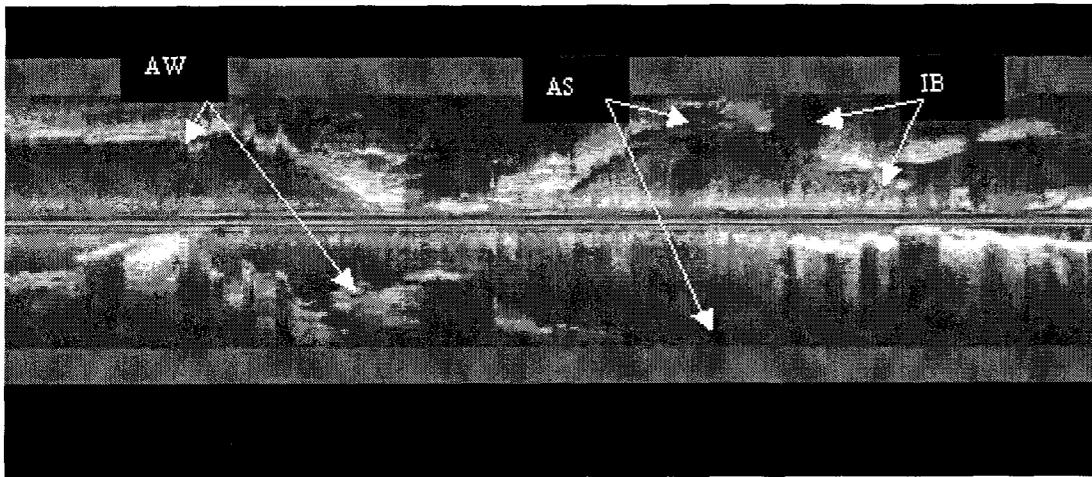


2) Feeling Virtual Catheter

3) Integration with Visual Feedback

Virtual Endovascular Surgery Demonstration (cont.)

4) Virtual Human Anatomy



5) Virtual Endovascular Procedures

6) Emulation of Procedure Complications

Conclusions

- A novel ElectroRheological Fluid Based Haptic Interface system was developed and it is called MEMICA
- MEMICA allows mirroring remote or virtual compliance and forces
- A series of applications are enabled including virtual endovascular surgery, exoskeleton support of disabled or physically impaired patients.
- As a support of virtual surgery it establishes novel virtual reality training tools, and enable control of therapeutic cardio-vascular operations in remote urgent care.

Acknowledgments

**NASA-Code S: JPL's Low Mass Muscles
Actuators (LoMMAs) Task**

Center for Advanced Information Processing (CAIP)